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Application of SVD-TR Model in Medical Image Analysis

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Abstract**—**An alteration or manipulation in digital images is termed as tampering. Tampering may be in any format- noise, content, distortion etc. Digital images have an inherent amount of noise introduced by either the imaging process or manual creation. Singular value decomposition (SVD) is one of the most important and useful factorizations in linear algebra. SVD is applied in removing the noise from digital images using linear calculations. In medical science, reports in digital form are corrupted by different type of noises. It is very important to obtain noise free images to facilitate accurate observations for further application. In this paper, an efficient SVD based noise detection and removal (SVD-TR) model has been used for analyzing and removing noise from medical images.

Keywords**—** Gaussian noise, SVD, tampering, medical images.

I. Introduction

Medical field is an important area of digital image application. In medical science, most of the diagnosis is based on digital images. Images obtained by optical, electronic, or electro-optic means are digitized for processing, displaying and archiving for further diagnosis. Various research issues are related with these images [1]. Image analysis involves extraction of meaningful information from images for further processing. Noise removal is one of the important issues in digital images. Errors or aberrations in the data and image capturing devices may generate image with certain noise that may lead to incorrect results or diagnosis. Distorted image needs to be preprocessed for effective feature extraction, analysis, recognition and quantitative measurements. It is required to remove unwanted signals from medical images for proper estimation and diagnosis [2]. Various noise-removing methods have been proposed. These include different filtering methods like median filtering, linear filtering, adaptive filtering etc.

Recently another method, Singular Value Decomposition (SVD) has been explored for removing different kind of unwanted content from input digital images. It is a very robust technique and finds a variety of applications in scientific computing, signal processing, automatic control, and many other areas. SVD is one of the most useful tools of linear algebra, which effectively reduces any matrix into a smaller invertible and square matrix. The small set called singular values preserve the useful features of the original image, which help in detecting or removing large extent of different types of alteration in digital images. Preliminary investigations indicate that a reasonable degree and type of noise may be detected and removed from digital images using SVD based noise removal technique. SVD can be further used for real time applications that involve online transmission of medical image analysis [4]. Thus, it is essential to explore the effect of SVD to develop interactive less time consuming and real time applications based on medical images that enhances the development of digital technology in the field of medical sciences. SVD based noise detection and removal (SVD-TR) model has been developed which has been proposed earlier [14]. The results shall be analyzed to investigate the effect and extent of noise removal from the input images. A brief mathematical overview of SVD is given below:

A. *Mathematical Model of SVD*

SVD is based on a theorem from linear algebra, which states that a rectangular matrix A can be broken down into the product of three matrices- an orthogonal matrix U, a diagonal matrix S, and the transpose of an orthogonal matrix V. The theorem is usually presented something like this:

$$A_{mn}=U_{mm}\ S_{mn}\ V_{Tnn}$$

where $U_TU= I$; $V_TV=I$; the columns of U are orthonormal eigen vectors of AAT , the columns of V are orthonormal eigen vectors of ATA and S is a diagonal matrix containing the square roots of eigen values from U or V in descending order [4]. Vectors can be further manipulated for controlling the extent and analysis of noise removal in digital image.

In this research study, digital medical images have been analyzed for noise removal. SVD can be used for many applications of medical sciences like diagnoses process, report generation, surgery etc. These processes involve image based inputs free of any distortion, tampering and noises for accurate and efficient diagnosis. A SVD based tampering removal model (SVD-TR) has been used in this research study for the estimation and removal of noise from medical digital images. Gaussian noise has been used as tampering in digital images to evaluate the performance of SVD-TR model.

II. Literature Review

Different researchers have proposed different techniques of noise removal. Various methods investigate effective features and applications of SVD. A brief research work in this area is discussed below:

T. Workaleman outlines different problems in digital image processing along with SVD filtering, image compression. The proposed filtering methods assume that the images have been degraded by a blurring application and the

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addition of noise. Experiments were performed for restoration and compression using SVD [5]. Another filtering action to reduce noise from image is studied by J. Harikiran et al. He proposed a novel technique for impulse noise reduction in which filters the noise parallely in five different smoothing filters. The denoised images obtained from five different filters are fused them to obtain a high quality image free from impulse noise [6]. A denoising scheme to restore images degraded by CCD is designed by H. Faraji et al. The proposed CCD noise model is a combination of signal independent and signal dependent noise terms. However, this model becomes more complex in image brightness space due to nonlinearity of the camera response function that transforms incoming data from light space to image space [7]. New fuzzy filter is presented for the reduction of additive noise for digital color images. S. Schutte designed two sub filters, which correct the pixels where the color components differences are corrupted to their environment. This method reduces the noise by using only edge detection method [8].

C. Chang et al. studied the noise reduction method for stripped image. The gray value substitution and wavelet transformation are satisfactory in stripped noise reduction. This model reduces the noise from stripped image [9]. An efficient operator splitting method for noise removal in images is proposed by D. Krishand et al [10]. A non-linear PDE based algorithm is developed based ideas proposed by M. Lysaker et al. It is a finite difference based additive operator method that allows much larger time slots [11]. S. Kumar et al. discuss feature extraction in digital image analysis. Gaussian noise removal method for removing noise from image collected is applied and then edge detection method is applied. Linear filters are not able to estimate impulse noise effectively as they have a tendency to blur the edges of an image [12]. On the other hand, non-linear filters are studied by V. Kavitha to deal with impulse noise [13]. The different variation of noise on digital image using SVD has been tested by D. Sharma et al. in the proposed model [14]. Another application of SVD based on face recognition is presented by T. Rasied et al. An algorithm is framed for face recognition by performing singular valued decomposition on the extracted feature of images. Training was carried out with back propagation neural network using ORL face database. By performing SVD on the extracted images, the size of input layer cells could be reduced by almost 99% compared to the initial size of the image [15].

D. Bartuschat et al. presented a new patch-based approach for the reduction of quantum noise in CT images. It utilizes two data sets gathered with information from the odd and even projections respectively that exhibit uncorrelated noise for estimating the local noise variance and performs edge-preserving noise reduction by means of the K-SVD algorithm. For image denoising, the K-SVD algorithm is used for training dictionary that describes the image content effectively. K-SVD has been adapted to the non-Gaussian noise in CT images. The proposed model shows the denoising results on synthetic and real medical data sets [16-17].

It is clear from the literature survey that no exhaustive work has been carried out in the noise removal process from digital images using SVD technique. Thus, an efficient SVD based noise removal (SVD-TR) model has been used.

III. PROPOSED METHOD

As explained above the objective of the proposed work is to investigate the effect of SVD techniques on the extent and the type of noise removal in selected domain of digital medical images. To carry out the experimental analysis, the digital medical images are used for processing and testing purposes. These images are easily prone to a variety of distortion such as noise that results in producing ambiguous information. In order to overcome such problems, a novel SVD based noise removal (SVD-TR) model has been used which has been proposed earlier. This model removes the noise from medical digital images. In this research study, to test the SVD-TR model, Gaussian noise produced by thermal noise has been incorporated in these input images. These images have been taken from three different types of medical image database – MRI, bone and chest image database set. More than 100 images have been tested and analyzed. Few of them are shown in Fig 1 [18]. The workflow of the proposed study for noise removal and the experimental analysis has been shown in next section.

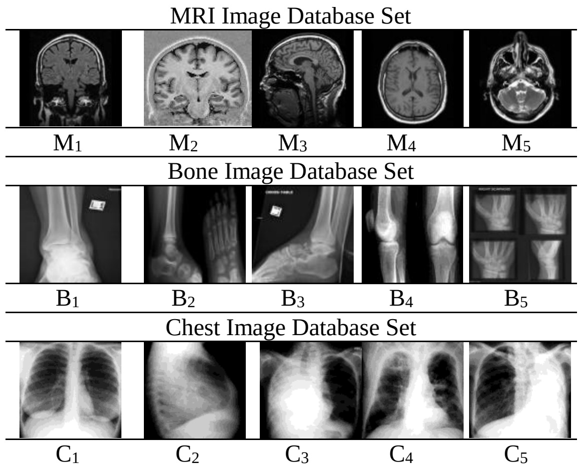

Fig. 1. Medical test image databases.

IV. METHODOLOGY

In the present research work, the SVD based noise removal (SVD-TR) model has been used for medical images as shown in Fig 2. The model describes the concept and workflow of SVD-TR model. This proposed system takes the original medical image from different standard database as input and after processing, generates the corresponding noise free images.

Image I has been taken from the set of selected database of medical images as input to the proposed system. After normalization, gaussian noise has been incorporated to I_N. SVD has been applied to I_N in order to extract the basic features of digital image, required for further testing. By using these features, noise can be detected and removed. The proposed SVD based detection and removal (SVD-TR) model

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has been applied to I_N to estimate the presence of noise and remove the maximum quantity of noise and generate a resultant noise free image *(I_{NF})*. I_{NF} has been compared with the corresponding original input image, *I* to calculate the extent of noise removal.

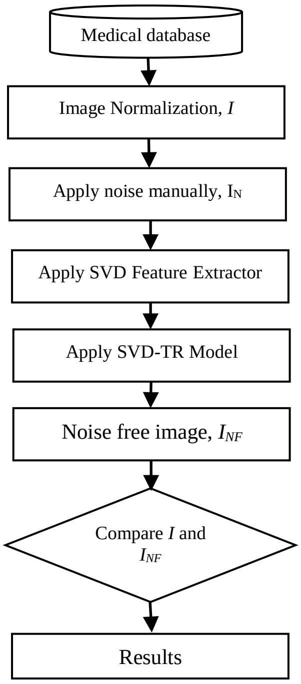

Fig. 2. Schematic diagram of proposed SVD-TR model for removing noise from medical images.

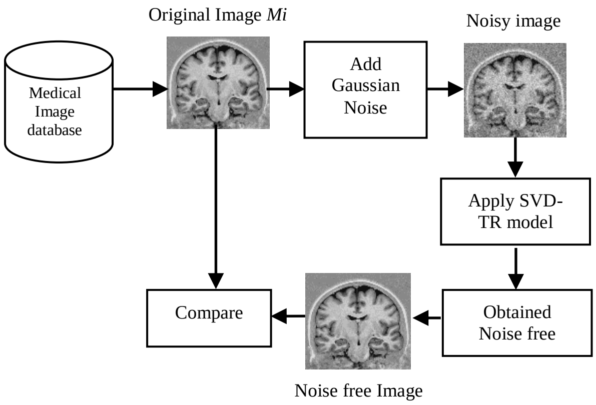

Fig. 3. Experimental work of proposed SVD-TR model for noise removal.

The experimental work of SVD-TR model for noise removal from medical digital images is shown in Fig. 3. Image, M_i has been chosen from medical image database as an original image. Gaussian noise has been incorporated at fixed mean and variance value. Then the SVD-TR model has been applied to remove the noise from the image and generate a corresponding noise free medical digital image. The resultant image is then compared with the original medical image, *Mi* in order to estimate the extent of noise removal using the SVD-TR model.

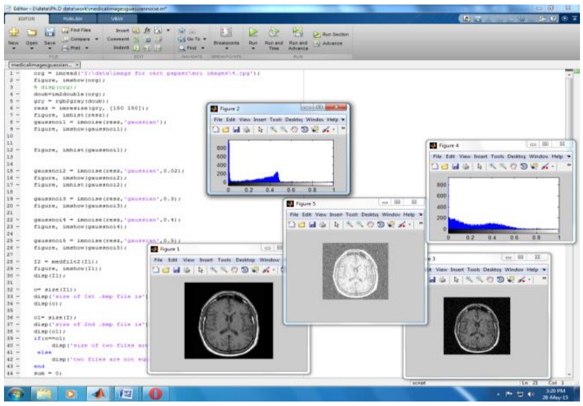

Fig. 4. Output for gaussian noise removal from medical digital images using SVD-TR model.

V. Results and Discussion

In this research study, SVD-TR model has been applied on three domains of medical images. The experimental results obtained for these different domains have been presented in Table 1. The image matches are in percentages obtained after comparing the processed output image with the original input image. The behaviour of different medical image from different standard database image sets after noise removal have been shown in Fig.5. It shows the comparison of different medical image sets [M], [B], and [C]. It is evident that SVD-TR removes induced noise from a minimum 60% to 87%. Set [B] shows comparatively better results.

Table 1 Extent of tampering removal from digital medical images (MRI, bone and chest images) using SVD-TR model.

MRI Images [M]		**Bone Images [B]**		**Chest Images [C]**	
Image	**Image Match**	**Image**	**Image Match**	**Image**	**Image Match**
M_1	68.54	B_1	70.87	C_1	68.74
M_2	73.86	B_2	76.02	C_2	67.92
M_3	78.94	B_3	72.95	C_3	63.92
M_4	63.14	B_4	89.12	C_4	69.62
M_5	76.52	B_5	88.65	C_5	87.82
M_6	77.26	B_6	68.21	C_6	70.92
M_7	84.25	B_7	73.92	C_7	82.82
M_8	80.54	B_8	86.63	C_8	81.82
M_9	79.13	B_9	71.93	C_9	70.54
M_{10}	78.25	B_{10}	87.92	C_{10}	79.03

A comparison of noise intensities have been done to analyze the impact of SVD-TR model in generating de-noise images. The intensity plots of three different image sets have been shown in Fig. 6. The 1^{st} column represents the intensity of the original test image, whereas second and third graph depicts the noise intensities obtained after inducing The noise intensities have also calculated to understand the disturbance in digital images with the addition of noise. There are three graphs shown in Fig 6 for different noise intensities for single image of each medical image database set. The first column of the graph represents the intensity of the original test image, whereas second and third columns depict the noise intensities present after inducing gaussian noise and then subsequent removal by SVD-TR respectively. As is evident, the resultant intensity plot generated shows considerable similarity to the original input indicating better noise removal.

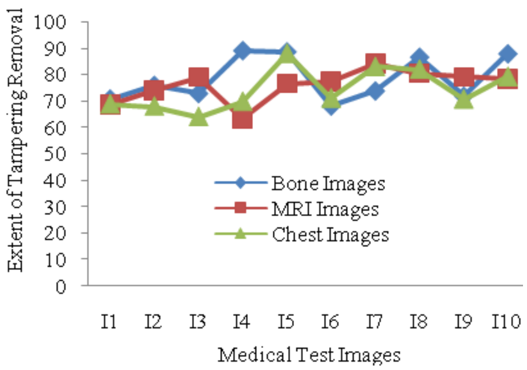

Fig. 5. Analysis of the medical test images after noise removal using SVD-TR model.

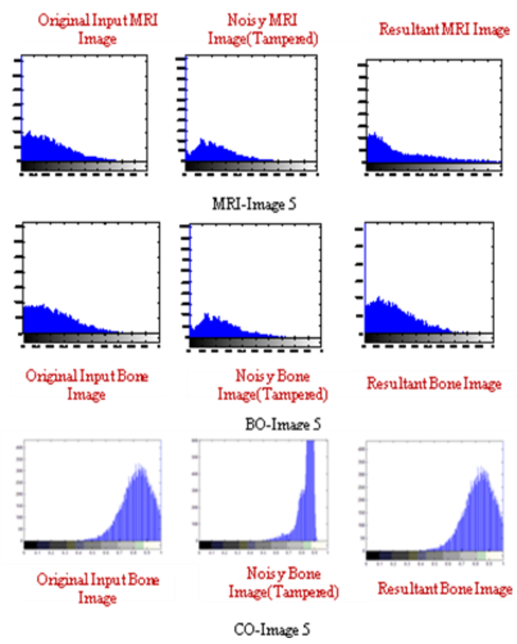

Fig. 6. Intensities of original image, noisy image and the resultant noise free image.

The analysis of results obtained from the entire data sets indicate that the SVD-TR model removes gaussian noise with an average of 74.5% from different domains of medical digital images. Max noise removal percentage is 89.12 for set [B] whereas the lowest match is 63.14 for Set [M]. Thus, the experimental results indicate that SVD-TR model works efficiently and in a consistent manner in removing gaussian noise from different medical image database set.

VI. Conclusion and Future Work

Digital techniques have been developed to enable CT, MRI and ultrasound scanning software to produce 3D images. For this, a robust and efficient method called SVD has been explored. Initial experiments suggest that as compared with other noise removal techniques, SVD can be used for many applications of medical sciences like diagnoses process, report generation, surgery etc. These all processes require accurate and efficient results that can be generated using the proposed SVD model.

In this research study, medical images from different selected image database set (MRI, bone and chest) have been taken for the experimental analysis. The gaussian noise has been added to large set of medical images. An interface has been developed to remove the induced noise from the input images using SVD-TR model. The result show that SVD-TR model removes the gaussian noise from the given test images with an average percent of 74.5 in all the domains of the medical test images. Therefore, based on the experimental study, it is established that SVD-TR model can be used for noise removal in the domain of medical image analysis with considerable efficiency. This proposed model can further be extended for complex and real time images and for interactive applications.

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